

Society of Amateur Radio Astronomers
Response to ET Docket N. 16-191, TAC Noise Floor Technical Inquiry

October 20, 2016

Federal Communications Commission
445 12 St NW
Washington, DC 20554

Introduction

The Society of Amateur Radio Astronomers (SARA) is an international society of dedicated enthusiasts who teach, learn, trade technical information, and conduct their own observations of the radio sky.

The organization is a scientific, non-profit group founded for the sole purpose of supporting amateur radio astronomy. SARA members actively teach and promote radio astronomy to youth in schools, clubs, and public events. SARA was founded in 1981, and today has hundreds of members worldwide.

Amateur radio astronomy generally includes the following radio bands:

ITU Band	Observations
SLF (30-300 Hz)	Natural, earth based phenomena – lightning, auroras, atmospheric reaction to solar activity
ULF (300-3000 Hz)	
VLF (3-30 kHz)	
LF (30-300 kHz)	
HF (3-30 MHz)	Jovian (Jupiter) and Solar activity
VHF (30-300 MHz)	Meteor detection, galactic sources (supernova, pulsars, hydrogen emission)
UHF (300-3000 MHz)	Galactic sources
SHF (3-30 GHz)	Demonstration - solar, lunar, research

Table 1. Radio bands of interest in amateur radio astronomy

Responses

We present our responses to the original inquiry questions as follows:

1. Is there a noise problem?

Absolutely, and it is progressively getting worse.

a. If so, what are the expected major sources of noise that are of concern?

There are many sources of noise that can adversely affect radio astronomy observations. The largest sources of noise by far are incidental radiators, which include (but are not limited to) some of the following devices:

- Dimmer switches for incandescent lighting
- Lighting – LED, (what other)
- LCD/Plasma televisions, computer monitors
- Switching power supplies for laptops, phone chargers, etc.
- Motor speed controllers – IGBT and PWM technology
- Hobby electronics – RC aircraft, drones
- Computing devices

Many of these devices generate large amounts of Radio Frequency Interference (RFI) by the use of internal oscillators which generate short duration signals with fast rise times, which by definition are high in harmonic content.

c. If incidental radiators are a concern, what sorts of government, industry, and civil society efforts might be appropriate to ameliorate the noise they produce?

RFI is essentially an engineering problem – it can be mitigated with proper use of shielding, ferrite cores, decoupling components, and other means. Unfortunately, such mitigation costs money. Equipment manufacturers will not use additional components to ameliorate RFI *unless required by law*. The law also needs to have more severe penalties than ones that are present at this time, in order to be effective.

A good analogy would be the automobile industry and the Environmental Protection Agency. Automobiles have many extra components added to reduce the pollution that they produce. Few, if any of these components are necessary to make the automobile operate. All of these components raise the cost of the automobile, as well as its complexity. Despite this, automobile manufacturers have been able to produce cars that are cleaner and more reliable than in the past, and yet are still affordable. Manufacturers that are caught subverting the law have faced severe penalties.

Stricter laws and more substantial penalties have to be put in effect to control the noise floor problem. Industry should be given a chance to implement voluntary standards, but the FCC needs to take charge in monitoring and enforcing them.

2. Where does the problem exist?

a. Spectrally

i. What frequency bands are of the most interest?

See Table 1.

b. Spatially

i. Indoors or outdoors?

Indoors tends to be more of a problem, as equipment is in closer proximity to incidental radiators. On the other hand, most (but not all) radio astronomy observations are performed by antennas mounted outdoors.

ii. Cities versus rural settings

With few exceptions, radio astronomy is impossible in urban areas. This is unfortunate, as inner-city students are generally deprived of the ability to enjoy radio astronomy. Rural areas generally have lower RFI levels, but they are getting progressively worse, with the proliferation of low-cost, poorly designed electronics.

iii. How close in proximity to incidental radiators and other noise sources?

This is highly dependent on the frequency spectrum of the radiator, and what it is connected to. If the geometry of the connected wiring is an efficient radiator at any of the frequency components that are given off by the radiator, the distances can be considerable.

iv. How can natural propagation effects be accounted for in a noise study?

It is dependent on the type of phenomena. Some natural phenomena are very regular and repeat diurnally (i.e., galactic background). These can be resolved out by spatial filtering (interferometry). Transient, unpredictable natural phenomena (lightning, meteors) can be removed by averaging over repeated measurements, or by integration methods.

c. Temporally

i. Night versus day?

The noise level is typically lower at night as the use of electronics is reduced. Radio observations are performed based on the visibility of an object of interest, so the observation may have to be performed when the noise floor is not at minimum.

ii. Seasonally?

No data could be found, but it stands to reason that LED Christmas lighting may be a larger contributor to RFI at particular times of the year.

3. is there quantitative evidence of the overall increase in the total integrated noise floor across various segments of the radio frequency spectrum?

b. What RF environment data from the past 20 years is available, showing the contribution from the major sources of noise?

Figure 1 shows a comparison over a four-year timespan.

4. How should a noise study be performed?

In response to the entire section 4:

In order to do a detailed study in a cost-effective manner, it would be a make sense to use volunteers. Groups like SARA, the ARRL, and the Radio Jove/Spectrograph Users Group have both the equipment and technical ability to perform these studies. There should be enough users spread around the United States to get good geographical coverage. Funding can be fairly minimal, as there are plenty of low-cost software-defined radio options available. Software may need to be written, but that can and should be done open source. There would need to be some entity in charge of gathering/archiving data, setting standards, and coordinating volunteers. NASA/Radio Jove is an excellent example of such as system. Observations of the Sun and Jupiter are archived and available for download. A standard software package is used to record and upload data. Calibration of data is encouraged, but not required

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(calibrated data has more value). Although there is a dedicated receiver for Radio Jove use that works very well, other receivers can be used, as long as they have sufficient performance.

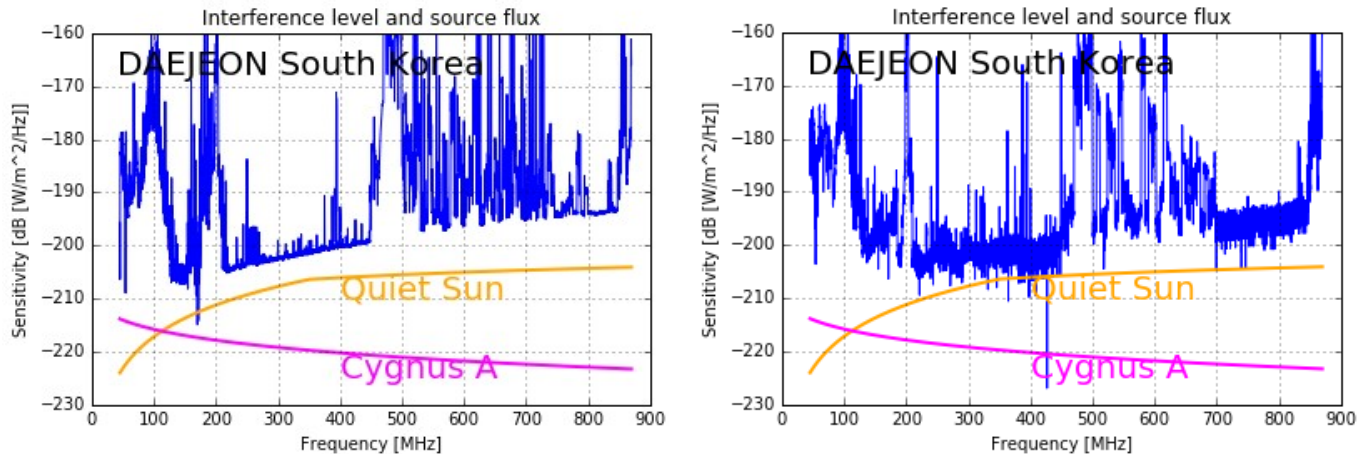


Figure 1. RFI measurements performed four years apart using a Callisto receiver designed for Solar observations. The left measurement was performed in 2012, the right one in 2016. The increase in noise floor is obvious in this comparison. Images courtesy of Christian Monstein.

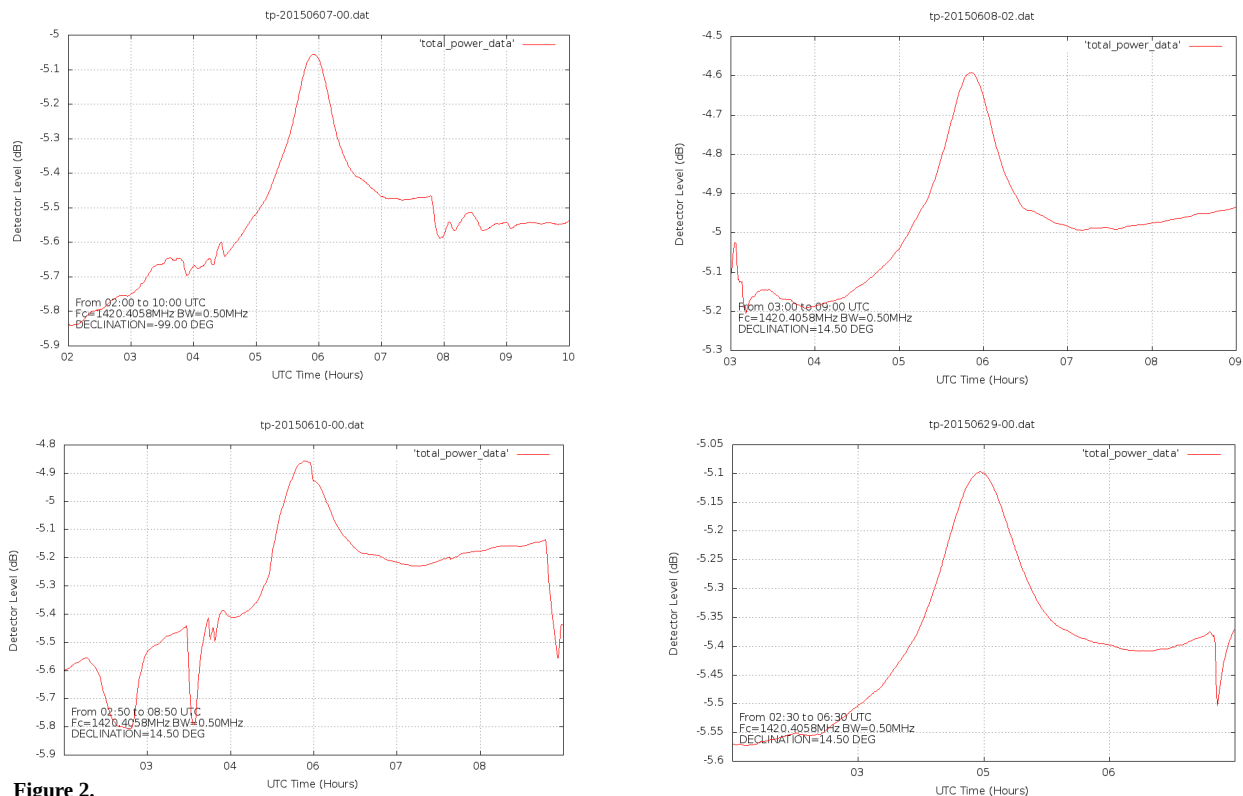


Figure 2. The author's attempt at recording radio source 3C400 on four separate occasions. Even though integration was used to filter out noise, large deviations in signal caused by intermittent RFI negatively affected each observation. These observations were made in a rural area.

Summary

Radio astronomy has been an extremely successful branch of science, and is responsible for much of our present knowledge about the universe. Due to availability of low-cost low noise amplifiers, it has become an extremely successful hobby as well. It is now possible to build a working radio telescope on nearly any budget, putting amateur radio astronomy in the classrooms of junior/senior high schools, as an excellent STEM (Science, Technology, Engineering, and Math) branch of study.

At the same time, the proliferation of low cost, poorly shielded electronics is rapidly causing a rise in the noise floor over a wide range of frequencies. This is affecting amateur radio astronomy adversely, as the sources that we seek are for the most part very weak. If we do not find a way to regulate the design and construction of consumer and industrial electronics that are corrupting the radio spectrum, we may end up wiping out an entire branch of science for good.